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# The Price of Gold: The Environmental Impacts of Toxic Chemicals in Gold Mining

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*SIT Study Abroad*

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# The Price of Gold: The Environmental Impacts of Toxic Chemicals in Gold Mining

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November 29<sup>th</sup>, 2007  
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## **ABSTRACT**

The role of mercury and cyanide in gold mining has become a hot topic in Mongolia in the past few years. In the past few months, the government has launched a crackdown on the illegal use of these chemicals in response to the contamination of Khongor soum's drinking water which resulted from an illegal mining operation. However, there are many more sites throughout the country that are in need of cleaning as a result of the illegal use of these chemicals by small companies as well as individual miners.

This paper examines the role of a variety of different views related to this issue. For example, the ability of the government to effectively regulate these chemicals is examined along with the use of these chemicals by legitimate companies such as Boroo Gold as well as the environmentally unfriendly use of these chemicals by operations such as Buman Trade and individual artisanal miners. Finally, the attempts to remedy this situation, ranging from the government's crackdown to attempts by multiple NGOs to teach miners alternative methods are examined.

Before this issue can be effectively resolved, Mongolia needs to upgrade its technology as well as its general approach to this issue. Currently, the country lacks the technology for local areas to test for, and clean up contaminated sites, and local governments are dependent on the national government for help. Finally, the country needs to address the root causes that lead people to become miners and allow access to these illegal chemicals. Only by taking this multi-faceted approach can Mongolia hope to solve this problem.

## **Glossary of Important Terms**

**Activated Carbon** – Small pieces of carbon that contain a very large surface area that is capable of “trapping” gold particles so they can be removed from a cyanide solution.

**Aimag** – The largest division of territory in Mongolia. There are 21 total aimags in the country, each with their own regional government offices.

**Amalgam** – A chemical mixture of mercury and another metal such as gold.

**Artisanal Miner** – Miners who work either on their own or in small groups. In Mongolia, the majority of artisanal miners mine gold at either placer or hard-rock sites. Their activities are technically illegal, though due to the large number of miners not much can be done to stop them. These miners are also often referred to as “ninja” miners.

**Hard-Rock Gold Mining** – Mining for gold that is encased in other rock. To recover the gold, the rock is ground into a fine powder and then the gold is separated by a variety of methods including the use of mercury and cyanide. Recent attempts have been made to introduce sluices that can compete with the recovery rates of these chemicals at hard-rock mine sites.

**Leaching** – The process of using cyanide to dissolve gold so it can be separated from the surrounding soil.

**Ninja Miner** – See “Artisanal Miner”

**Placer Gold Mining** – Mining for gold that requires only water and a filter to separate chunks of gold. This type of mining is used when the gold occurs as large pieces rather than small particles.

**Sluice** – A “filter” that is used to recover gold. The ore is placed on the sluice and water is added to help move the ore. As the ore travels down the sluice the components are separated so that gold can be recovered.

**Soum** – The second largest division of territory in Mongolia. Within each aimag there are multiple soums. Each soum has its own environmental officers and other important government officials.

**Tugrug** – The Mongolian currency. As of December 2007, \$1USD is approximately equal to 1,170 tugrug(MNT).

## **Methodology**

This intention of this project is to examine the role of mercury and cyanide in the Mongolian gold mining industry and the environmental impacts these chemicals have. Obviously, in order to understand this issue, meetings with the individuals and companies directly involved with the use of these chemicals played a very important role in the research stage. In addition, artisanal “ninja” miners, the NGOs trying to address the problem, and specialists in the areas of mercury and cyanide issues were interviewed to learn more about the status of the problem. This approach was chosen to gain a variety of perspectives on the issue in order to better understand how each position fit into the big picture. The length of the ISP period definitely acted as the biggest limitation on this study. With the large number of potential interview subjects available, sacrifices had to be made in order to ensure that all perspectives received attention. Additionally, outside research was necessary to understand how the situation of Mongolia compared to other countries. Since numerous agencies such as the United Nations and the World Bank have all studied certain aspects of this topic these reports became a starting point for the project.

## **Introduction**

### ***THE PROBLEM***

Since 1990, the gold mining industry in Mongolia has exploded to become a major contributor to the overall economy. During this period of time, the number of gold mining plants increased from only 3 in 1990 to 133 in 2005<sup>1</sup>.

Along with this increase in the number of gold mining companies, the number of

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<sup>1</sup> *Present Status of the Mining Sector*. 25 Oct. 2007.  
< <http://www.mit.pmis.gov.mn/en/modules.php?name=News&file=article&sid=47>>.

artisanal “ninja” miners also increased drastically. During the communist times and the first few years after the formation of Mongolia’s new government ninja miners did not exist in any substantial numbers. Within the last ten years however, the number of people partaking in this activity has exploded and although reliable estimates are hard to come by, it is thought that during the summer when mining peaks, there may be more than 100,000 ninja miners throughout the country<sup>2</sup>. A growing problem among these miners as well as some of the new mining companies is the use of toxic chemicals such as mercury (Мөнгөн ус in Mongolian) and cyanide (Цианид). Though there are exceptions, there are many instances where these chemicals are used without any sort of regulation which can easily lead to disastrous consequences for the environment and the people living in the area. This danger became apparent in early 2007, with the discovery of very high levels of mercury and cyanide in Khongor soum in northern Mongolia which led to the death of three cows and one sheep and put the entire population at risk.

#### *USAGE OF TOXIC CHEMICALS*

In gold mining there are two major types of operations which vary greatly in the techniques required to extract the gold. Placer mining has historically existed as the dominant form of gold mining in Mongolia and is a very simple process. Placer mining is very effective at capturing large pieces of gold. As a result, this method is employed in areas where the gold present is fairly large in size. The basic way of separating the gold from the unwanted soil involves only

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<sup>2</sup> Grayson, Robin. *Anatomy of the People’s Gold Rush in Modern Mongolia*. World Placer Journal. 2007, 7. 1-65.

gravitational methods. Since gold is much denser than the surrounding soil, these methods, which do not require any chemicals, can be easily utilized using only water<sup>3</sup>. Perhaps the best example of this method of mining can be found in the Zamaar region west of Ulaanbaatar in Tov aimag. At this site there are numerous official gold mining companies as well as hundreds if not thousands of ninjas all using gravitational methods to recover gold<sup>4</sup>.

Unfortunately, every gold deposit is not suited to this method. The main alternative to placer mining is known as hard-rock mining and typically requires much more work to extract the gold. Hard-rock gold deposits can contain much smaller gold particles in the soil as well as much lower concentrations of gold in general. Historically, gravitational methods have been much less effective at recovering this type of gold resulting in the use of chemicals instead. Even now, despite recent advances in gravitational methods, it is often the case that chemical methods, including the use of both mercury and cyanide, are the most economical method for retrieving the gold<sup>5</sup>.

The use of mercury is the simplest of the chemical methods of gold recovery and according to most sources has been present in Mongolia since the late 1990's. The soil that contains gold is ground into a fine powder and then mercury is added forming an amalgam with the gold. The remaining soil is then removed leaving only the mercury-gold amalgam. Initially, the desired product is

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<sup>3</sup> *The Basic Process of Gold Recovery*. Denver Mineral Engineers Website. 11 Nov 2007. <<http://www.denverminerals.com/basic~1.html>>

<sup>4</sup> D. Bayanbat – General Director of Gold & Cashmere, Datsan Trade Company. Personal Interview. 2 Nov 2007. Ulaanbaatar, Mongolia.

<sup>5</sup> *Use of Cyanide in the Gold Industry*. International Cyanide Management Institute Website. 2 Nov 2007. <[http://www.cyanidecode.org/cyanide\\_use.php](http://www.cyanidecode.org/cyanide_use.php)>

placed inside a finely perforated piece of cloth. When squeezed, any excess mercury is removed and is generally collected for repeated use. The amalgam is then heated, which causes the mercury to evaporate and only the gold is left behind<sup>6</sup>. The problem with this process is that there is inevitably some mercury lost to the surrounding environment. The discarded soil certainly contains mercury and the heating process evaporates gaseous mercury into the air (most of which condenses and falls back to the ground in the areas around the mills). Another limitation of mercury is that it does not amalgamate with very small gold particles and as a result only about 30% of the gold in the soil can be recovered using mercury<sup>7</sup>. In this case, the discarded soil, which is contaminated with mercury, also typically contains 70% of its original gold.

One solution to this problem is to use cyanide, which is the most popular way of extracting gold among mining companies worldwide<sup>8</sup>. There are a few variations of the cyanide process, but they all are based on the same basic idea. The rock is crushed into small pieces and eventually cyanide (in the form of a sodium cyanide solution) is added which causes the gold to dissolve. The liquid, which contains the dissolved gold, is then drained and treated further. There are multiple ways of recovering the gold, but whatever method is used, the result is the same. The gold is recovered from the solution, and the remaining cyanide solution is either treated and disposed of or recycled for repeated use.

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<sup>6</sup> G. Altantsetseg – former ninja miner. Personal interview. 8 Nov 2007. Khanbogd Soum, Mongolia.

<sup>7</sup> G. Buyantogtokh – National Emergency Management Agency Specialist. Personal Interview. 1 Nov 2007. Ulaanbaatar, Mongolia.

<sup>8</sup> *The Basic Process of Gold Recovery*. Denver Mineral Engineers Website. 11 Nov 2007. <<http://www.denverminerals.com/basic~1.html>>

As simple as the process sounds, every step along the way must be carefully controlled in order to ensure safety. For this reason, cyanide usage has the potential to be very dangerous if not carried out in a professional manner by people with proper training, and even the slightest mistake can lead to disaster. Cyanide can be used safely in a manner that does not harm the environment or people but if the proper safety precautions are not in place, then cyanide is nothing more than another poison.

#### *THE DANGERS OF MERCURY AND CYANIDE*

Mercury and cyanide are both very dangerous chemicals and the presence of either chemical in the environment is a serious problem. Throughout the world there are a multitude of organizations that exist solely to ban the use of these chemicals. The main environmental danger of both of these chemicals is that once in the environment they present serious health risks to people who come in contact with them. Beyond this general danger, the specific dangers of the two chemicals are very different.

Mercury is metal that exists as a liquid under standard conditions. It is highly toxic to both humans and animals, though the effects of its toxicity may take months or years to become apparent. Mercury is especially dangerous because of its bioaccumulative properties. This means that the body has no way of eliminating mercury from the body so repeated exposure to small amounts will lead to a build up of mercury inside the body. Mercury does not dissolve in water so it tends to persist in the areas where it is first introduced as opposed to spreading throughout an area. If left in the environment, mercury will not break

down into less dangerous chemicals but simply remain until it is removed, either by cleaning or being taken up by an animal or plant. Therefore humans can be exposed to mercury simply by eating plants or animals suffering from mercury exposure and this will also lead to accumulation inside the body.

Cyanide, while also a very toxic chemical has many of the opposite properties of mercury. Cyanide is also highly toxic to animals and humans, and if exposed to a lethal dose, death can result in a matter of minutes<sup>9</sup>. Cyanide readily dissolves in water and can therefore be easily spread throughout an area. When used in mining, cyanide is found in the ionic form  $\text{CN}^-$  which is only stable when the pH of the solution is over 10. Under environmental conditions (which have a much lower pH of around 7) cyanide is converted to hydrogen cyanide gas in the presence of water. Hydrogen cyanide gas is also extremely toxic to most organisms. The one benefit that cyanide has over mercury is that it does not persist in the environment. Cyanide is reactive and will gradually break down by reacting with the surrounding environment, and in some cases the byproducts are completely harmless. Therefore, while a cyanide spill is a very serious threat initially, it will slowly decompose to less toxic products unlike mercury which will remain indefinitely. Finally, cyanide does not accumulate in the body and so there is not much fear of cyanide poisoning from eating other plants or animals.

The other danger of these two chemicals is that they can react with each other. Cyanide and mercury will react to form mercuric cyanide,  $\text{Hg}(\text{CN})_2$ , which like plain cyanide is water soluble and can therefore be carried from one area to

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<sup>9</sup> *Environmental and Health Effects of Cyanide*. International Cyanide Management Institute Website. 2 Nov 2007. <[http://www.cyanidecode.org/cyanide\\_environmental.php](http://www.cyanidecode.org/cyanide_environmental.php)>



another. Mercuric cyanide can pose an environmental risk because when exposed to heat or light it can decompose back to separate mercury and cyanide. There has not been much study of this compound and so the actual risks are not known, but it is thought that this compound could pose an environmental risk since it is a potential source of both mercury and cyanide.

### **Government Aspects**

#### *THE LAW*

According the section 1, article 3 of the Toxic Chemicals Law, which Parliament approved on April 15, 1995:

“Chemicals and substances which influence human health, environment, wild and domestic animals and pose a risk of death or extermination (except radioactive, intoxicating, and tranquilizing chemicals and chemicals used for households, food ingredients and medical preparations) belong to the category of toxic chemicals.”<sup>10</sup>

Based on this statement, both cyanide and mercury clearly fall under this classification as toxic chemicals. In fact, within this category, there are three other possible classifications. Toxic chemicals can be classified as either mildly toxic, toxic, or highly toxic<sup>11</sup>. Depending on which category chemicals fall under, there are different rules regarding the use of these chemicals. Cyanide is regarded as “highly toxic” while mercury is considered so toxic that its use is banned except in research labs with special permission.

Chemicals that are classified as “mildly toxic” or “toxic” require the permission of the local soum governor in order to be used. All of the legal paperwork and monitoring is handled at the soum level and companies or

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<sup>10</sup> *Commercial Laws of Mongolia*. C. Ariuna, O. Mashbat, Ed. The Legal Information Center. Ulaanbaatar, Mongolia. 2002.

<sup>11</sup> G. Buyantogtokh – National Emergency Management Agency Specialist. Personal Interview. 1 Nov 2007. Ulaanbaatar, Mongolia.

individuals using chemicals must report to these local authorities. Chemicals like cyanide, which are classified as “highly toxic”, require permission from the national government before they may be used. Companies must submit annual reports on the use of these chemicals to the national government proving that proper safety precautions are in place. For highly toxic chemicals, special permits are also required to both import and store chemicals.

Mongolia also has established limits on the amounts of both cyanide and mercury that are permissible in drinking water. For cyanide, the limit is 0.01ppm (parts per million) while for mercury the limit is 0.0005ppm or 0.5ppb (parts per billion). Surprisingly, there is no limit for these chemicals in the soil, but if the need arises the government consults the World Health Organization (WHO) standards or the limits set by other countries<sup>12</sup>.

Mongolia also has laws regulating mining activities. According to the Minerals Law of Mongolia passed in 1997, companies must submit environmental impact reports which include rehabilitation plans for the areas they intend to mine. Additionally, these companies must set aside funds that act as a deposit and will be returned after the mine successfully cleans up after its operation<sup>13</sup>. The general consensus (even among many environmental organizations) is that these laws provide a solid legal framework regulating both the role of toxic chemicals and the responsibilities of mining companies. Unfortunately, simply creating the laws is not enough to ensure a safe environment. According to Ts. Munkhbayar,

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<sup>12</sup> Khulan – Inspector, State Professional Inspection Agency. Personal Interview. 13 Nov 2007. Ulaanbaatar, Mongolia.

<sup>13</sup> *Commercial Laws of Mongolia*. C. Ariuna, O. Mashbat, Ed. The Legal Information Center. Ulaanbaatar, Mongolia. 2002.

who heads an NGO that fights mining operations located near vulnerable rivers, “The laws are not bad, but the laws are not being followed”<sup>14</sup>.

Another issue that is discussed frequently is the role of artisanal miners in Mongolian mining. Currently this type of mining is illegal, but due to its popularity, there are efforts to legalize this activity. The Sustainable Artisanal Mining (SAM) Project has helped lead the way in this field. This agency created a draft law to legalize artisanal mining and provide a framework for regulating the miners similar to the laws governing mining companies. The agency submitted the first draft on June 5<sup>th</sup>, 2006<sup>15</sup>. Since that time, the law has been repeatedly revised and updated as all sides try to reach an agreement. One of the major problems with illegal artisanal mining is that there is no regulation of the use of toxic chemicals at hard-rock mining sites. The proposed law seeks to address this issue while still allowing artisanal miners to work. Under this new law, the use of mercury would be explicitly forbidden. In the same section, the law forbids the use of any toxic chemicals that are addressed by other laws, which includes cyanide<sup>16</sup>. In addition to banning these chemicals, the law calls for tougher punishments for people caught using these substances including the possibility of serving time in jail. While the passage of the law would certainly be a big step towards addressing the problem of illegal chemical use by artisanal miners, it is important to remember that simply passing a law will not fix the situation

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<sup>14</sup> Ts. Munkhbayer – Head of Onggi River Movement. Personal Interview. 20 Nov 2007. Ulaanbaatar, Mongolia.

<sup>15</sup> “A Draft Law on Artisanal and Small Scale Mining is Under Discussion by the Parliament for Approval”. Sustainable Artisanal Mining Project in Mongolia. 27 Nov 2007. <<http://www.sam.mn/index.php?id=113&lang=0&cont=66>>.

<sup>16</sup> “Mongolian Law on Small Scale Mining (Draft)”. Sustainable Artisanal Mining Project in Mongolia. 27 Nov 2007. <<http://www.sam.mn/index.php?id=113&lang=0&cont=66>>.

overnight, and that only by enforcing the law and addressing the actual causes of the problem can Mongolia hope to rid itself of its mercury and cyanide problem.

### *THE AGENCIES*

The three main government agencies that deal with mercury and cyanide issues are the National Emergency Management Agency (NEMA), the State Professional Inspection Agency (SPIA), and the Ministry of Nature and Environment (MNE). The role of each agency is well defined with respect to the authority each agency has. While discussing the issue of mercury and cyanide, one agency often claimed not to know about a procedure or law because it fell under another agency's jurisdiction.

The Ministry of Nature and Environment is responsible for regulating the transportation, storage, and cleanup of chemicals<sup>17</sup>. As part of this responsibility, the organization also grants permission to companies to use highly toxic chemicals such as cyanide. In order to gain permission, companies must submit Environmental Impact Assessment reports detailing the risks of using the chemicals as well as plans for how to deal with an accident. These reports are reviewed by MNE officials to determine if a company receives a license. The Ministry also handles all of the paperwork associated with chemical usage. Each year companies must compile reports on chemical usage, storage, and any incidents involving chemical accidents. These reports are submitted to the MNE which determines if companies are abiding by the law.

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<sup>17</sup> S. Erdentsetseg – Officer, Department of Environment and Natural Resources. Personal Interview. 21 Nov 2007. Ulaanbaatar, Mongolia.

The State Professional Inspection Agency basically acts as a police force dedicated to enforcing the toxic chemical laws. This agency is responsible for making sure companies and individuals are not using chemicals such as cyanide illegally, and that the general waste from mines does not contain dangerous levels of toxins. The agency also investigates areas where pollution is reported to determine if sites are contaminated and in need of cleaning. Given the large number of mining sites throughout the country, the agency is typically only able to test each company once a year to see if they are operating within the law<sup>18</sup>. If companies are violating the law, then the SPIA has the authority to shut down their operations until the situation is remedied. During the Khongor incident, the SPIA's role consisted of monitoring the surrounding areas to verify that the decontamination process was effective at removing the toxic chemicals.

The agency is a general watchdog that makes sure everything is operating smoothly without actually affecting policy. For example, if a company is shut down by the SPIA, it is still up to the Ministry of Nature and Environment to decide whether or not to revoke the company's license.

The National Emergency Management Agency is the government organization responsible for the actual cleanup of polluted sites around the country. Given the amount of illegal mining that has existed in recent years, this organization faces a daunting task. A recent report stated that in just nine aimags in central and southern Mongolia there is over 200,000 tons of soil polluted with

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<sup>18</sup> Khulan – Inspector, State Professional Inspection Agency. Personal Interview. 13 Nov 2007. Ulaanbaatar, Mongolia.

mercury and cyanide<sup>19</sup>. NEMA does not actually investigate sites itself but waits until either the SPIA or the local people report a site polluted. The agency then decides on a plan of action for cleaning sites, often with advice from outside organizations such as the WHO.

### *THE FAULTS*

As with any bureaucracy, there are inefficiencies and everything does not run smoothly. Mongolia is no exception when it comes to dealing mercury and cyanide. Within the government framework there are many problems that need addressing so that these environmental problems can be dealt with more effectively. For example, despite a generally strong legal framework Mongolia does not have clear limits for some chemicals. There are permissible levels of cyanide and mercury in drinking water, but there is no standard for the amount of cyanide allowed in soil, and as a result the SPIA often has to turn to guidelines from the WHO or other countries to decide if an area needs cleaning. Due to the variety of guidelines from other countries this strategy can result in much confusion and debate over when to classify a site as polluted.

There also seems to be a general lack of knowledge on dealing with this type of environmental problem. According to one of the SPIA's officers, when the Khongor incident came to light, the agency did not know how to deal with the situation and was forced to consult sources on the internet in order to learn possible ways of cleaning the site<sup>20</sup>. Supporting this belief, a recent United

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<sup>19</sup> G. Buyantogtokh – National Emergency Management Agency Specialist. Personal Interview. 1 Nov 2007. Ulaanbaatar, Mongolia.

<sup>20</sup> Khulan – Inspector, State Professional Inspection Agency. Personal Interview. 13 Nov 2007. Ulaanbaatar, Mongolia

Nations report on the clean-up of Khongor soum cited that while NEMA successfully cleaned the site, the organization lacked proper equipment and acceptable procedures to ensure the safety of the workers taking part in the decontamination process<sup>21</sup>.

Another problem with the government's approach to this issue is that there seems to be very little government presence outside of Ulaanbaatar. While each aimag and soum has environmental officers, these people often lack training in recognizing and cleaning up chemical pollution. All of the laboratory facilities are in Ulaanbaatar meaning that local governments cannot even test for contamination themselves. One of Omongov aimag's environmental officers claimed that his office had identified many sites in need of cleaning, but the aimag simply cannot handle the job. Instead they just sent a request to the central government for help and are currently waiting for a reply. The only measures the aimag is capable of taking are to cover polluted sites with plastic sheets and keep them wet in order to keep contaminated soil from blowing away<sup>22</sup>.

The agencies themselves are also quick to point fingers at their counterparts in rival agencies when discussing mercury and cyanide pollution. The officer from the MNE claimed that local governments are more responsible for handling pollution problems than the national government. She also claimed that if the SPIA had detected the pollution in Khongor soum earlier then the

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<sup>21</sup> *Sodium Cyanide and Mercury Pollution and Mining Related Environmental Emergencies in Mongolia*. July 2007. United Nations Environmental Programme. 21 Oct 2007 <<http://ochaonline.un.org/ochaunep>>.

<sup>22</sup> B. Otgonbayar – Environmental Land Policy Specialist. Personal Interview. 6 Nov 2007. Dalanzadgad, Mongolia.

problem would have been much less serious<sup>23</sup>. Similarly, both NEMA and SPIA officials blamed the Ministry of Nature and Environment for allowing Buman Trade, a company that uses cyanide to extract gold, to operate despite their objections over its lack of environmental controls.

### **Khongor Incident**

The issue of mercury and cyanide in mining suddenly entered the public domain when news of pollution in Khongor soum broke. This single event has already had dramatic impacts on this issue which had previously received too little attention.

#### ***WHAT HAPPENED***

On April 23<sup>rd</sup>, 2007 three cows and a sheep were found dead in Khongor soum, approximately 200 km north of Ulaanbaatar. Tests showed that these animals contained mercury in their bodies. Government scientists collected samples for analysis and the results showed that the area contained high amounts of both mercury and cyanide. The subsequent investigation discovered that this pollution resulted from an illegal mining operation located nearby. The miners had dumped their polluted water into the city water supply which had overflowed to produce a small lake of polluted water as well as contaminating the surrounding soil and air.

According to the SPIA, the soum's drinking water contained 0.26ppm of cyanide which is many times the allowed limit of 0.01ppm. The soil in the area contained around 20-25ppm of cyanide, but as mentioned before there is no

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<sup>23</sup> S. Erdentsetseg – Officer, Department of Environment and Natural Resources. Personal Interview. 21 Nov 2007. Ulaanbaatar, Mongolia.



official Mongolian standard for soil cyanide levels. The wastewater that the operation produced contained an astounding 747.5ppm cyanide (for comparison this concentration would provide a lethal dose of cyanide from drinking less than one glass of water)<sup>24</sup>. Based on the amount of contamination present, the government recognized the need to cleanup the site immediately, so NEMA was sent in to handle the situation.

### *THE CLEANUP*

The decontamination process began on May 17<sup>th</sup>, 2007 and concluded on the 25<sup>th</sup> of that month. Based on the advice of foreign organizations, Mongolia used an Australian product called DTOX that is designed specifically to clean both mercury and cyanide contamination in water. DTOX is a solution of Sodium Polysulfide ( $\text{NaS}_x$ ) that is simply added to contaminated water and basically requires no additional work. The benefit of this product is that it successfully eliminates both cyanide and mercury simultaneously which worked perfectly for Khongor soum. The final products of the decontamination are also safe and typically do not require any additional treatment. Mercury is precipitated out as mercury sulphide ( $\text{HgS}$ , better known as the mineral cinnabar) while cyanide is decomposed to sodium bicarbonate (baking soda) and sodium nitrate (which is taken up by plants)<sup>25</sup>. In total, NEMA decontaminated 18.5 tons of cyanide solution, approximately 44,000m<sup>2</sup> of soil, and 560m<sup>2</sup> of water. Additionally, the

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<sup>24</sup> Khulan – Inspector, State Professional Inspection Agency. Personal Interview. 13 Nov 2007. Ulaanbaatar, Mongolia.

<sup>25</sup> *Sodium Cyanide and Mercury Pollution and Mining Related Environmental Emergencies in Mongolia*. July 2007. United Nations Environmental Programme. 21 Oct 2007 <<http://ochaonline.un.org/ochaunep>>.

Boroo Gold Mine which is located nearby agreed to take 1,192 tons of soil containing both mercury and cyanide to be treated at their facility<sup>26</sup>.

### *THE AFTERMATH*

In the months following the decontamination, the SPIA took air, soil, and water samples every two weeks to make sure that no residual mercury or cyanide contamination existed. Ms. Khulan, one of the SPIA's inspectors who dealt with the incident, willingly showed the results of this sampling to prove that mercury and cyanide contamination in Khongor soum no longer existed. Ms. Khulan admitted that despite this monitoring and the dissemination of these results, people did not believe that the danger had passed. In fact, Ms. Khulan claimed that the average Mongolian citizen does not trust the SPIA's results and still believes that the area is unsafe<sup>27</sup>. A recent newspaper article gave further credence to this opinion. On November 1<sup>st</sup>, 2007, the UB Post reported that the government had bought all of Khongor soum's vegetables (14 metric tons) because the residents could not sell them due to fears of contamination. Tests showed that the vegetables did not contain any mercury or cyanide, but people remained skeptical<sup>28</sup>.

Luckily, the Khongor incident is the only major incident of mercury and cyanide contamination that Mongolia has faced so far<sup>29</sup>. Given the amount of contamination in the area, it is lucky that the only casualties amounted to 4

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<sup>26</sup> Khulan – Inspector, State Professional Inspection Agency. Personal Interview. 13 Nov 2007. Ulaanbaatar, Mongolia.

<sup>27</sup> Ibid.

<sup>28</sup> "Aimag Buys up Vegetables". UB POST. Vol. 44. 1 Nov 2007.

<sup>29</sup> G. Buyantogtokh – National Emergency Management Agency Specialist. Personal Interview. 1 Nov 2007. Ulaanbaatar, Mongolia.

livestock. In the wake of this disaster though, the government finally began to accept that something needed to be done about the mercury and cyanide issue. Previously, the government had turned a blind eye towards the use of these chemicals. While cyanide usage is a much newer phenomenon, mercury usage had existed for many years prior to the Khongor incident. During this time, mercury use was widespread among ninjas at hard-rock gold sites and hardly any effort was made to hide the use of this toxin. In fact, one former ninja miner claimed that before Khongor, everyone knew about mercury use and the police did not care so he never worried about getting caught<sup>30</sup>.

In the past, the government did, however, make some efforts to have at least minimal control over the use of mercury and cyanide. Both of these chemicals became very popular among ninja miners in Omongov aimag in recent years. As a result, in September of 2006, the aimag government negotiated with the miners and the two groups managed to forge an agreement. The government recognized that stopping all mining activity would not be possible, so instead they managed to convince the miners to consolidate their operations. Therefore, instead of having an unknown number of mining sites throughout the aimag causing widespread pollution, the government established three sites where miners could work. Mercury and cyanide still played a role in the mining process, but at least the government knew where the pollution existed so they could make sure that polluted sites did not pose a risk to people or livestock<sup>31</sup>.

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<sup>30</sup> G. Mendbayar – Former ninja miner. Personal Interview. 15 Nov 2007. Ulaanbaatar, Mongolia.

<sup>31</sup> B. Otgonbayar – Environmental Land Policy Specialist. Personal Interview. 6 Nov 2007. Dalanzadgad, Mongolia.

This apparent feeling of indifference towards the use of these chemicals changed after the Khongor incident. The government acted quickly to condemn the use of these chemicals and call for a halt to all illegal use of mercury and cyanide. During the summer of 2007 police and government agents rounded up the mills used by ninjas mining hard-rock sites and confiscated any mercury or cyanide found. In Khanbogd soum alone, officials confiscated 33 mills used to crush the gold-containing rock before mercury and cyanide are added. According to several ninja miners, the government crackdown has shown it self to be at least somewhat effective. Many mining operations have stopped their work both due to a lack of mills and a fear that using mercury and cyanide now is too risky given the government's attitude towards the miners<sup>32</sup>. Certainly there is less illegal usage of both mercury and cyanide than before the crackdown, but according to former ninjas who admitted to using mercury, there are still people using both mercury and cyanide<sup>33</sup>. The users have only become more secretive and therefore the odds of the government successfully stopping the pollution of the environment resulting from the use chemicals seems low.

### **Mining Companies**

The Ministry of Nature and Environment is responsible for granting companies permission to use cyanide for gold mining. Currently, the companies with this permission are Boroo Gold, a Canadian company operating in Selenge aimag, MGH Company, a Mongolian company in Omongov aimag, and Ten Hun,

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<sup>32</sup> G. Altantsetseg – Former ninja miner. Personal interview. 8 Nov 2007. Khanbogd Soum, Mongolia.

<sup>33</sup> G. Munktemee – Former ninja miner. Personal Interview. 15 Nov 2007. Ulaanbaatar, Mongolia.

a Chinese company. Buman Trade, which also operates in Omongov had its permission to use cyanide revoked in June 2007 after a visit by the State Professional Inspection Agency revealed inadequate safety precautions<sup>34</sup>.

### *BOROO GOLD*

Boroo Gold is one of the companies with government permission to use cyanide. This Canadian company began mining gold in 2004 in Selenge aimag, north of Ulaanbaatar. Each year, this operation uses approximately 660 tons of sodium cyanide to extract gold from the soil<sup>35</sup>. The basic procedure requires that the ore is ground into small pieces and then mixed with quicklime (Calcium Oxide – CaO) and water to make a slurry that contains the gold particles. This step is important since it ensures a high enough pH that hydrogen cyanide gas will not be created when the cyanide is added. The cyanide is added in the form of a 10% solution of sodium cyanide, and the overall ratio is approximately 200 grams of cyanide per each ton of ore<sup>36</sup>.

The gold is removed from the cyanide solution using activated carbon and the remaining cyanide is separated and sent on for detoxification. This cleaning process consists of three large tanks where several chemicals are added in order to clean the water of any toxic chemicals. Before the water is pumped out to the tailings pond, the levels of free cyanide (CN<sup>-</sup>, or the form of cyanide used to dissolve gold), weak-acid dissociable (WAD) cyanide (cyanide bound to a metal

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<sup>34</sup> S. Erdentsetseg – Officer, Department of Environment and Natural Resources. Personal Interview. 21 Nov 2007. Ulaanbaatar, Mongolia.

<sup>35</sup> Suren – Boroo Gold Environmental Officer. Personal Interview. 14 Nov 2007. Selenge aimag, Mongolia.

<sup>36</sup> Ocirbat – Boroo Gold Metallurgist. Personal Interview. 14 Nov 2007. Selenge aimag, Mongolia.

such as copper or iron that can easily be a source of free cyanide), and arsenic (another toxic chemical that is sometimes present at low levels in mining operations) are all monitored to ensure that the water is safe. Before decontamination, the two cyanide levels are both typically 40ppm and the arsenic level is around 10ppm. After the detoxification process is complete the levels of all of these chemicals are less than 1ppm<sup>37</sup>.

The actual decontamination process involves adding sulfur dioxide (SO<sub>2</sub>) and oxygen (O<sub>2</sub>) causing cyanide (CN<sup>-</sup>) to be converted into cyanate (CNO<sup>-</sup>) which is then pumped out to the tailings pond. Cyanate is a much less toxic chemical than cyanide and when exposed to water and sunlight, it further decomposes to ammonium carbonate, (NH<sub>4</sub>)<sub>2</sub>CO<sub>3</sub>, a chemical that is not a major environmental concern. The mine monitors this process at every step to ensure that there is never any danger to the surrounding areas. According to the mine's environmental officer, there are many safeguards in place to ensure that dangerous levels of cyanide are not leaked to the environment<sup>38</sup>. The water that is being discharged to the tailings pond is tested every two hours to verify that the amount of both cyanide and arsenic in the water is less than 1ppm. Additionally, every week the air, water, and soil around the sites where cyanide is stored and used are tested to make sure that no accidental release has taken place. Finally, within the area where tailings are deposited there are numerous sensors spaced throughout the lake and soil that are tested monthly to determine cyanide and

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<sup>37</sup> Ocirbat – Boroo Gold Metallurgist. Personal Interview. 14 Nov 2007. Selenge aimag, Mongolia.

<sup>38</sup> Suren – Boroo Gold Environmental Officer. Personal Interview. 14 Nov 2007. Selenge aimag, Mongolia.

arsenic levels. In addition to submitting its water samples to the Mongolian government for analysis, the company also sends duplicate samples to the United States for verification of the results.

Boroo's safety measures also extend beyond the simple monitoring of the waste produced. The cyanide is imported from China, and every person who comes in contact with it during its journey to the Boroo mine has undergone training on the risks and dangers of cyanide. Additionally, the company is even going so far as to set up a program to train the local government inspectors on methods of testing for cyanide and mercury pollution in the environment along with methods for cleaning up this pollution. The company's operation is very impressive, and everyone came across as very open and honest about the cyanide issue. Suren, one of the mine's environmental officers, even disclosed that there had been one incident where the cyanide level remained above the allowed limit during the detoxification process which resulted in the entire mill being shut down until the problem was resolved. While the cyanide level violated the company's limit for its waste, the wastewater never actually left the mill and as a result no environmental contamination occurred.

During a tour of the facilities where cyanide is used, it became apparent that Boroo carefully monitors all of the processes involving cyanide. There are many sensors located throughout the building that constantly monitor the pH of solutions containing cyanide (to ensure that hydrogen cyanide gas is not produced), the rate at which cyanide is added to the crushed ore, and the amount of hydrogen cyanide gas present inside the building. Overall, the safety

precautions taken by Boroo Gold both for gold extraction and for the cleaning of the cyanide waste seem indicative of a safe and environmentally conscious operation that minimizes the risk of polluting the surrounding areas.

### *BUMAN TRADE*

Buman Trade (Буман Трэйд) is another company involved with the usage of cyanide in gold mining. Every person asked about this company offered a slightly different account of the situation, and even a personal visit to the site did not entirely clear up the confusion. The company is located in Omongov aimag, approximately 78 kilometers south of Khanbogd soum. In this very remote corner of the Gobi Desert, Buman Trade runs a gold washing operation that uses cyanide. The company does not mine any ore itself, but simply takes the mercury-laden soil from ninjas and other mining companies. Since mercury is ineffective at recovering gold particles beyond a certain size, the “waste” soil that is left behind after using mercury often contains as much as 70% of its original gold. This mercury rich soil (called Шлам in Mongolian) is then leached using cyanide in order to extract this remaining gold.

After talking to multiple government officials, the status of Buman Trade’s operation is still not entirely clear. According the Ministry of Nature and Environment, the SPIA shut down Buman Trade in June 2007<sup>39</sup> and as a result the Ministry no longer grants the company permission to use cyanide. The Inspection Agency confirmed this, but also stressed that they did not approve of the operation even when it had permission from the Ministry of Nature and

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<sup>39</sup> S. Erdentsetseg – Officer, Department of Environment and Natural Resources. Personal Interview. 21 Nov 2007. Ulaanbaatar, Mongolia.



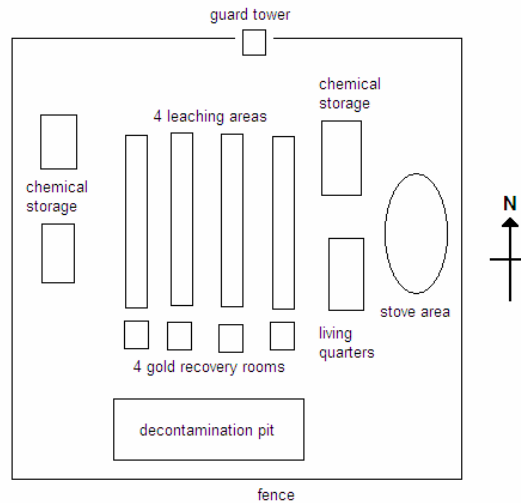
Environment<sup>40</sup>. However, the environmental inspector of Khanbogd soum (where Buman Trade is located) told a different story. According to her, the company resumed working in August of 2007 with permission from the Ministry of Nature and Environment and is currently operating and extracting gold<sup>41</sup>.

The first thing that stood out about Buman Trade was its location. The site is located about two hours south of Khanbogd by jeep. The road leading to the site is very barren, with only two or three gers visible during the whole trip. The operation is situated about twenty miles north of the Chinese border, and near the borders of Gobi Special Protected Areas. The site is obviously meant to discourage visitors given its distance from any sort of civilization. The operation itself is not very impressive. The tallest building of any sorts is a guard tower overlooking the site that stands about fifteen feet (about 7 meters) high. There are several small brick buildings that are used to recover gold and store chemicals. The actual leaching pots are made by simply building a dirt wall up from the ground and lining the bottom with a thin plastic sheet. There are four rows of leaching pots, each with eight pots per row. Each row contains a small pit for decontamination and there is one additional large pit that is also used for the same purpose. Finally, at the edge of the camp there are several in-ground stoves that are used to melt the recovered gold so it can be formed into larger pieces.

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<sup>40</sup> Khulan – Inspector, State Professional Inspection Agency. Personal Interview. 13 Nov 2007. Ulaanbaatar, Mongolia.

<sup>41</sup> O. Namjilmaa – Environmental Inspector, Khanbogd Soum. Personal Interview. 7 Nov 2007. Khanbogd Soum, Omongov aimag, Mongolia.



**Figure 1 - A rough map of the Buman Trade site setup.**

While nobody was present at the site during the visit (the guard had apparently left soon before our arrival), an exploration of the site yielded many interesting finds. Walking around the site gave an eerie feeling. Though everything appeared deserted, lots of evidence suggested otherwise. The environmental inspector seemed surprised to find that all 32 pots contained soil (each one can hold ten tons) given that the previous week the pots had been mostly empty and the company claimed to be emptying the others<sup>42</sup>. Additionally, one of the ovens used to melt gold was found to still be warm on the inside despite nobody being present at the site. This indicates that Buman Trade is still working and using cyanide despite having their license apparently revoked by the Ministry of Nature and Environment.

The use of cyanide by this company does not appear to be regulated with the same amount of care as Boroo Gold's operation. Since the site was deserted, it was not possible to hear specific details about the process used to extract gold.

<sup>42</sup> O. Namjilmaa – Environmental Inspector, Khanbogd Soum. Personal Interview. 8 Nov 2007. Буман Трэйд site, Mongolia.

However, due to the simple setup of the site, many details about the operation could simply be inferred from observation. All of the pots where the cyanide is mixed in with the gold are open to the air and are lined with only a thin layer of plastic. This is a dangerous practice because as mentioned before, if the pH of the cyanide solution is not carefully regulated then hydrogen cyanide can be produced. While it is likely that the pH is regulated initially, once the cyanide is exposed to the open air there is no way of monitoring the mixture. This means that there is no way of knowing if hydrogen cyanide gas is being released into the air. All of the pots are lined with thin plastic sheets as a precaution to keep the cyanide from leaking and contaminating the surrounding soil. This is certainly better than nothing, but one government specialist claimed that while ninja miners and other small operations such as Buman Trade often make attempts to prevent contamination of nearby areas, their efforts generally are ineffective<sup>43</sup>.

The decontamination process at Buman Trade appears to be at best half-hearted, with the possibility that there is really nothing going on. The area around the decontamination pit contained many open bags of white powder. According to the environmental inspector, these bags simply contained salt and Buman Trade used this as their decontamination procedure. The fact that she did not fully understand the process is reason enough for concern. Clearly the company has not educated the inspectors on the details of their operation which is integral to ensuring that the inspectors can do their jobs. Since the inspector does not know

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<sup>43</sup> G. Buyantogtokh – National Emergency Management Agency Specialist. Personal Interview. 1 Nov 2007. Ulaanbaatar, Mongolia.

the details of the operation she can not easily judge whether Buman Trade is really doing what they claim to do.

As for using salt in the decontamination process, Buman Trade's method is not likely to actually help break down cyanide. Adding salt to a solution containing cyanide can lead to its decomposition, but only if an electrical current is applied to the solution. Without a current, no significant destruction of cyanide occurs. There was no apparent setup that could administer a current near the decontamination area, and given the isolated location of Buman Trade, it is unlikely that the site even has the option of electricity.

According to the Environmental Inspector, there is no real monitoring of the Buman Trade operation. Neither Khanbogd soum nor the whole Omongov aimag has the equipment to test for contamination in the area. Occasionally government surveys come to the area and take samples back for analysis, but these visits are generally few and far between. The inspector goes down to check on the operation occasionally, but given the large amount of land under her jurisdiction and the prevalence of illegal mining in this part of Mongolia she must focus her attention elsewhere at times.



**Figure 2 - The cyanide tanks at Buman Trade. The white containers underneath the tank are empty 50kg tubs of sodium cyanide.**

The only possible redeeming factor about this operation is that due to its isolated location the chances of its pollution endangering people is very slim since the surrounding area appears virtually uninhabited. This view is similar to one expressed by the officer at the Ministry of Nature & Environment. She acknowledged that Buman Trade did not follow rigorous safety codes and their equipment needed upgrading. However, she claimed that by having Buman Trade in operation, the government knew where the pollution existed and could at least make attempts at controlling it. She argued that without Buman Trade, individual miners would be spread throughout the entire region and would wash their waste soil individually resulting in pollution of many sites that the government could not oversee<sup>44</sup>.

#### *ARTISANAL MINERS*

Artisanal miners, who are often referred to simply as “ninjas”, first started appearing in Mongolia in 1998<sup>45</sup>. While estimates of the number of ninjas

<sup>44</sup> S. Erdentsetseg – Officer, Department of Environment and Natural Resources. Personal Interview. 21 Nov 2007. Ulaanbaatar, Mongolia.

<sup>45</sup> Appel, Peter W. Uitterdijk. *Small Scale Mining in Mongolia – A Survey Carried Out in 2004*. Danmarks Og Grønlands Geologiske Undersøgelse Rapport 2005/4. 2005.

working in Mongolia have gone over 100,000, not all of these are involved in mercury and cyanide usage. The majority of ninjas do mine gold, but even among these miners there are two main types. Many miners work at placer deposits where water and a pan are all that is needed to extract gold. Various organizations have studied the environmental impacts of this type of mining<sup>46</sup>, but as far as mercury and cyanide go, these miners are not a source of these chemicals. Miners who work at hard-rock sites are a different story though. Hard-rock gold sites typically require the use of chemicals to extract the gold, and it is these sites that have come to the public's attention due to the use of mercury and cyanide by the miners.

The issue of artisanal mining is a very hot topic right now. On one hand, the process is illegal, but given the number of people participating, and the fact that many of the miners have no other option for work, many people have simply come to accept the fact that the miners will always be present. However, since miners typically work by themselves or in small groups, they have to rely on very simple and cheap technology in order to recover gold. In the past this has meant the widespread use of mercury at hard-rock sites. Certainly there are reports of small, Mongolian-owned companies polluting sites with mercury and cyanide<sup>47</sup>, but unfortunately for the ninjas they seem to be responsible for much of the pollution.

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<sup>46</sup> The World Bank (2006), the International Labor Office (2006), and the World Placer Journal (2007) all have reports on artisanal miners at placer sites that discuss the effects of these miners on surrounding areas.

<sup>47</sup> B. Bulgamaa. UB POST. 11 Oct 2007.

Based on previous studies<sup>48</sup>, as well as interviews carried out with former ninja miners, most miners are aware of the dangers of mercury. However, the fact that an assistant miner who does not own his own mill can make over 1,000,000 tugrug per year using mercury leads many people to ignore these dangers<sup>49</sup>. In placer sites ninjas often work individually but at hard-rock sites, where mills are needed to grind the rock, it is more common to find small teams of miners working together. The teams use mills to grind rock, and then add mercury and water. The mercury-gold amalgam is then filtered out and any excess mercury removed.

All of the ninjas interviewed claimed that attempts were made to reuse the excess mercury that is separated in this step; however, given the crude nature of the process it is likely that some is lost to the environment. Finally, the amalgam is heated to drive off the mercury. This is the most environmentally unfriendly step since the mercury evaporates, only to condense and fall back down to the ground where it contaminates nearby areas. Since mills need water in order to operate they are often located near rivers and streams. As a result these sources of water easily become polluted from miners working nearby. This is an even larger problem in the Gobi where water is often hard to come by.

When the water becomes polluted it is not just a threat to humans, but as seen with the Khongor incident, animals are also at risk. According to the environmental inspector in Khanbogd, the surrounding area used to contain a

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<sup>48</sup> B. Tumenbayar. *Action Research on Mercury Pollution in Boroo Area in Mongolia*. Japanese International Cooperation Agency 2005.

<sup>49</sup> Ts. Ishigbaatar – Former ninja miner. Personal Interview. 7 Nov 2007. Khanbogd soum, Mongolia.

large number of wild animals, but now many have died off. While the validity of this claim can not be verified, the inspector clearly believes that ninjas are to blame for polluting much of the surface water that animals rely on<sup>50</sup>.

As for the chemicals themselves, the ninjas stated that these are simply brought in from China. According to the ninjas, smuggling in chemicals does not pose a challenge, and in many cases bribes are not needed<sup>51</sup>. Cyanide is apparently only available from China, and the majority of mercury comes from there too. However, the miners claimed that it is possible to buy mercury from Naraantuul Market in Ulaanbaatar, a claim that a Mongolian newspaper recently substantiated<sup>52</sup>. The ninjas quoted different prices for mercury, but for one kilogram of mercury the average price is somewhere between 70,000 tugrug and 100,000 tugrug. Depending on how much rock the miners processed and the actual make-up of the rock, miners typically use between 1 and 3 kg of mercury per year<sup>53</sup>.

Previous studies on the use of mercury have determined that despite ninjas claims of recycling mercury, around 40% of the mercury added to the crushed rock ends up either in the waste soil or waste water, and possibly as much as 50% of the original mercury ends up being evaporated into the air<sup>54</sup>. If these numbers

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<sup>50</sup> O. Namjilmaa – Environmental Inspector, Khanbogd Soum. Personal Interview. 8 Nov 2007. Буман Трэйд site, Mongolia.

<sup>51</sup> G. Mendbayar – Former ninja miner. Personal Interview. 15 Nov 2007. Ulaanbaatar, Mongolia.

<sup>52</sup> B. Tsetserdelger. *Нарантуул Захад Мөнгөн Ус Зарж Байна*. Өдрийн Сонин. 261. 2 Nov 2007.

<sup>53</sup> G. Altantsetseg – Former ninja miner. Personal interview. 8 Nov 2007. Khanbogd Soum, Mongolia.

<sup>54</sup> B. Tumenbayar. *Action Research on Mercury Pollution in Boroo Area in Mongolia*. Japanese International Cooperation Agency 2005.



are accurate, then each mill in operation is likely adding 1 – 2 kilograms of mercury to the surrounding environment every year.

In the months preceding the government crackdown, the heart of these ninja operations existed in Omongov aimag. The original wave of ninja mining had largely spared the Gobi, but after the discovery of the Oyu Tolgoi copper/gold deposit the area began to receive more attention. Mercury use started as early as the year 2000, but became widespread in 2003, much later than other areas, and cyanide did not arrive until 2005<sup>55</sup>. According to several miners who worked in this area, cyanide was reserved for the more professional operations and very few Mongolians actually used this chemical. Cyanide operations were apparently run by Chinese workers, and though Mongolians may have assisted with these operations, only the Chinese actually handled the cyanide<sup>56</sup>. According to one ninja who worked in the area near Buman Trade, between forty and fifty mills, each operated by a group of miners existed in the surrounding area<sup>57</sup>. Based on the popularity of this region among ninjas and the fact that the deposits are mainly hard-rock sites that require mercury and cyanide it should come as no surprise that a recent study reported that this aimag contains the largest amount of contaminated soil in Mongolia<sup>58</sup>.

A common practice among ninja miners is to take their mercury-laden tailings to Buman Trade in order to extract the remaining gold. For their services,

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<sup>55</sup> G. Altantsetseg – Former ninja miner. Personal interview. 8 Nov 2007. Khanbogd Soum, Mongolia.

<sup>56</sup> Ts. Ishigbaatar – Former ninja miner. Personal Interview. 7 Nov 2007. Khanbogd soum, Mongolia.

<sup>57</sup> G. Mendbayar – Former ninja miner. Personal Interview. 15 Nov 2007. Ulaanbaatar, Mongolia.

<sup>58</sup> G. Buyantogtokh – National Emergency Management Agency Specialist. Personal Interview. 1 Nov 2007. Ulaanbaatar, Mongolia.

Buman Trade receives either 100,000 tugrug per ton of tailings leached or half of the gold that is recovered<sup>59</sup>. As mentioned before, this does help to localize the pollution and prevent individual miners from using cyanide which despite not being a good practice is at least better than the worst-case scenario.

### **The NGOs**

#### *THE ROLE OF NGOs IN MINING*

With the incident at Khongor and the resulting government crackdown on mercury and cyanide still fresh on the public's mind, there is a growing concern over the use of toxic chemicals in Mongolia. This debate ultimately leads back to the controversy over artisanal mining since the two are so interconnected.

Numerous NGOs have sprung up in recent years to try to address this situation.

#### *SAM PROJECT*

The Support for Artisanal Mining (SAM) Project is one of the projects run by the Swiss Agency for Development and Cooperation (SDC). This agency works with both miners and lawmakers in order to reach a compromise on artisanal mining. Instead of simply writing off artisanal mining as illegal, this organization is committed to allowing miners access to this source of income that often acts as their only support. However, the agency recognizes that artisanal mining cannot continue in its present state. The unregulated use of toxic chemicals is not an acceptable practice given the risks to people and the environment. To combat this, the SAM Project has plans to implement two projects that will hopefully teach miners alternative methods of recovering gold.

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<sup>59</sup> G. Mendbayar – Former ninja miner. Personal Interview. 15 Nov 2007. Ulaanbaatar, Mongolia.

The first project involves the use of gravitational methods to separate the gold. By using sluices (basically a filter to separate gold from unwanted soil) with very fine mesh filters, it is possible to recover very small gold particles. The other project is slightly more technical and uses centrifuges to separate gold from waste soil based on the density of gold which is much greater than most other minerals<sup>60</sup>. Both of these projects are still in the pilot phase, and if they prove effective and feasible for miners then they will be expanded to larger areas.

This agency is also heavily involved in drafting a new law on artisanal mining. The agency submitted its own version of a draft law in June of 2006 and since then has worked with Parliament to revise the law. This law, if implemented, would provide a framework for allowing regulated and legal artisanal mining that is free (at least on paper) of toxic chemicals. The agency works closely with members of Parliament to constantly revise this law and remains hopeful that an updated version will be passed in the near future.

#### *PACT MONGOLIA*

The SAM Project is not the only organization that is attempting to teach artisanal miners about alternative methods of gold recovery. PACT Mongolia has instituted a wide-reaching campaign to educate the general public about the dangers of mercury and cyanide. This campaign has a unique approach that strives to provide miners and those around them with information about the dangers of mercury and cyanide along with safer alternatives. Instead of simply telling miners that these chemicals are bad, PACT's goal is to teach people how

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<sup>60</sup> N. Davaasambuu – Technical Expert, SAM Project. Personal Interview. 24 Oct 2007. Ulaanbaatar, Mongolia.

chemicals are initially introduced to the environment as well as the resultant effects on people's health<sup>61</sup>. The campaign utilizes posters, t-shirts, hats, stickers, and notebooks that are distributed to people of all ages and occupations so that all members of society become educated to the point of wanting change.

PACT also follows the principle that change is gradual. It is not reasonable to expect miners to simply give up the use of mercury overnight, especially since many people rely on mining as their main source of income. Instead the organization advocates initially that miners who are using mercury adopt safer methods, such as using a retort<sup>62</sup>. Retorts are simple, cheap pieces of equipment that allow for as much as 95% of mercury to be recycled for repeated use<sup>63</sup>. Miners are then encouraged to adopt methods of gold recovery that are free of both mercury and cyanide. To this end, PACT, along with the NGO Sans Frontiere Progres, is also promoting the use of sluices to recover gold. Dr. Tumenbayar, the head of Sans Frontiere Progres, recently educated miners on the use of these sluices and distributed fifty of them throughout the Gobi region<sup>64</sup>.

Based on tests performed by Dr. Tumenbayar, these sluices are capable of recovering more gold than if only mercury is used, and cost less than \$100 USD to construct. Ideally, these sluices will one day be more effective than using cyanide, but this is currently not the case. Cyanide and mercury are currently the most profitable way of recovering gold, but PACT is hoping that by teaching

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<sup>61</sup> Ullman, Ondine – Technical Advisor for Education, PACT Mongolia. Personal Interview. 27 Nov 2007. Ulaanbaatar, Mongolia.

<sup>62</sup> Ibid.

<sup>63</sup> Appel, Peter W. Uitterdijk. *Small Scale Mining in Mongolia – A Survey Carried Out in 2004*. Danmarks Og Grønlands Geologiske Undersøgelse Rapport 2005/4. 2005.

<sup>64</sup> B. Tumenbayar – Director, Sans Frontiere Progres. Personal Interview. 27 Nov 2007. Ulaanbaatar, Mongolia.

miners about these safer alternatives there will be a shift away from mercury and cyanide. To this end, the organization has also published materials on how miners can build their own retorts and sluices.



**Figure 3 - One of PACT's mercury awareness posters**

The PACT campaign appears to be reaching its target audience. PACT posters and stickers can be seen decorating the walls of government offices in both Dalanzadgad and Khanbogd as well as a hotel in Khanbogd. Ironically, even one of the buildings at Buman Trade contained a poster warning about the dangers of cyanide and mercury. Additionally, aimags that were not initially targeted by the campaign are now starting to request that PACT provide them with materials to distribute to their citizens<sup>65</sup>.

## **Conclusions**

The issue of mercury and cyanide in gold mining is very complex. One study cannot possibly encompass every aspect of this issue to a satisfactory degree. However, based on the information presented above, it is possible to draw some conclusions about the present situation and make a few

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<sup>65</sup> Ullman, Ondine – Technical Advisor for Education, PACT Mongolia. Personal Interview. 27 Nov 2007. Ulaanbaatar, Mongolia.

recommendations about how to remedy some of the problems. However, a caveat must be placed on all of the following conclusions. Mongolia is not capable of fixing these problems overnight. Some of these issues will take many months (or years) and lots of money and political commitment to fix. These issues must be addressed in a rational manner if the solutions are to be long lasting. In some instances, baby steps are necessary for change to occur. For example, the Omongov government recognized that it could not possibly eliminate the use of toxic chemicals in the aimag. Instead, the government decided to focus on limiting the extent of the pollution. The government approved three sites where miners could work. This agreement did not eliminate the amount of toxic chemicals being used, but it made it so that the government could better control the pollution and did not have to worry about widespread contamination of the soil. Certainly the government cannot simply stop here, but by addressing the problem one step at a time the chance for success is much greater.

### *TECHNOLOGY*

Probably one of the most significant factors in mercury and cyanide pollution is the lack of proper technology or the knowledge to use technology in an effective manner. Artisanal miners know that mercury and cyanide are dangerous, yet they continue to use them. In most cases, these miners are only looking for a way to provide for their families. They willingly expose themselves to the dangers of these chemicals because in their minds there is no alternative. By educating miners about possible alternatives and making the technology (i.e. sluices and retorts) available, the amount of environmental pollution from

artisanal miners could significantly decrease. NGOs such as PACT Mongolia and the SAM Project are helping to pave the way, but they need assistance. It is not feasible for these NGOs to supply this technology to the thousands of miners who work at hard-rock sites, but the Mongolian government as well as foreign governments could help supplement this type of program.

As for the mining companies, larger operations such as Boroo Gold generally have the proper technology to ensure that chemicals such as cyanide can be used in a safe manner. However, it is also necessary to educate workers so that the technology is used in the proper fashion. The Boroo operation certainly appears to take this matter very seriously and so far their safety record supports this belief. However, there are many smaller companies that operate both legally and illegally which do not follow the same standards. The most obvious example of this is Buman Trade. Ignoring the uncertainty over its present legal status, the fact that it once operated with government permission should come as a shock given the status of its equipment. The soil that is washed with cyanide is held in place with walls made of dirt and completely open to the air. The apparent decontamination process is ineffective, and the Ministry of Nature and Environment knows most of this. A Ministry officer acknowledged that the machinery used at this site is outdated, but argued that Buman Trade had the advantage of centralizing the use of cyanide. While this may be the case, the company can certainly take more precautions without much additional effort, and further study is needed to determine exactly how this company affects the role of

cyanide use in the area and whether it actually reduces cyanide use by individual miners.

Finally, the technology used to monitor mercury and cyanide pollution is in need of improvement. Currently soum and even aimag governments are not capable of testing for mercury and cyanide pollution. Unfortunately, in some instances, even the government in Ulaanbaatar is not capable of performing these tests. When the Khongor incident broke, samples had to be sent to both China and Korea for analysis<sup>66</sup>. Fixing this problem will not be an easy (or cheap) task. However, given that these chemicals are still present in society, local governments need to be able to detect sources of contamination as early as possible so that they can be isolated and the threat removed. In general, more thorough training on the procedures for dealing with contaminated sites needs to be established for all levels of government. Without this upgrade, Mongolia will always be at risk for another Khongor-type incident with the potential for much more serious results.

Along with monitoring, the identification of mercury and cyanide needs to be improved. According to a member of the SPIA, customs officials at border checkpoints know to look for mercury and cyanide smugglers, but apparently receive little actual training on identifying mercury and cyanide<sup>67</sup>. These border points are the main channel through which illegal chemicals are brought into the country, and by simply educating the inspectors it should be possible to decrease

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<sup>66</sup> Khulan – Inspector, State Professional Inspection Agency. Personal Interview. 13 Nov 2007. Ulaanbaatar, Mongolia.

<sup>67</sup> Khulan – Inspector, State Professional Inspection Agency. Personal Interview. 13 Nov 2007. Ulaanbaatar, Mongolia.



the amount of chemicals that are smuggled past inspectors. Unfortunately, there are also reports of bribes being used to guarantee safe passage of chemicals. While this is a much more difficult issue to address, any improvement, no matter how minor, will have the positive result of fewer illegal chemicals in the country.

### *GOVERNMENT*

In the past few months the government has made a noble effort to try to limit the use of mercury and cyanide. While this is certainly a step in the right direction, there is still much room for improvement. The current legal framework seems sufficient for regulating toxic chemicals; although Mongolia needs to address the role artisanal miners will play in the future of Mongolia's mining sector. This need could be met with the passage of the draft law proposed by the SAM Project, but until a final revised version of this law is released, any comment on its impacts would simply be speculation. What is missing on the legal side is the enforcement of the law. There are too many examples of illegal activities operating without any pressure from law enforcement. Also, according to the ninjas, the ease with which mercury and cyanide are brought into the country illegally is astounding and needs remediation if Mongolia hopes to rid itself of the illegal use of these chemicals.

The government agencies who deal with mercury and cyanide need to establish more cooperative relationships and focus less on blaming each other and more on finding ways of addressing this issue. For example, blaming the State Professional Inspection Agency for not detecting the pollution in Khongor soum early enough does little to help prevent the next environmental disaster, but

sharing information on the location of known areas of illegal operations might.

Admittedly, the agencies did work together to clean up this disaster, but until this becomes the norm, there will be room for improvement.

The general attitude of the government towards mercury and cyanide could also use an overhaul. The current feeling seems to be that it is important to eliminate all illegal mercury and cyanide use as quickly as possible. This is certainly an admirable goal, but given the large number of artisanal miners and companies using these chemicals it is not really feasible. Instead, the government should follow the approach taken by PACT and the SAM Project and try to convince the miners to change on their own. To help promote this change, government funding for a project to build and distribute a number of new sluices to miners would probably have a much greater impact on the use of toxic chemicals than simply arresting and fining a few unlucky miners who get caught.

One of the difficulties in trying to address the status of artisanal miners is the fact that for many miners the gold they recover serves as the major part of their income. Simply stopping the miners' activities is not a feasible approach since it does not address the actual cause of the problem. Instead of just focusing on the mining aspect, an effort also needs to be made to address the social issues that lead people to become miners. If these social factors are addressed, then it should follow that fewer people will turn to mining, and as a result fewer toxic chemicals will be used. A perfect example of this came out of an interview with a former ninja miner in Omongov aimag. The miner had worked for two years with a small group of miners during which he used mercury to recover gold. He knew

of the dangers of his work and when he found another job (which paid less, but did not include the risks associated with illegal mining) he immediately left his job as a ninja<sup>68</sup>. By improving the opportunities for legal work in impoverished areas with mining potential, the government can tackle two problems at once by eliminating unemployment and reducing the risk that people will turn to artisanal mining as an alternative.

Certainly the government situation has improved though. Given that just over a year ago miners openly used mercury without much fear of getting caught, the government has finally begun to assert itself. Hopefully time will show that the government realizes that simply bullying people is not the way to bring about change and will instead focus on reasoned, practical approaches to reducing pollution.

#### *POLLUTED AREAS*

As bad as the Khongor incident was, it did help teach Mongolia how to deal with a contaminated site. Hopefully, the country will be able to apply this to the large number of polluted areas spread across the country. Many of these sites have sat for years with no real measures being taken to prevent their contaminating other sites. Mongolia learned an effective method for cleaning up both mercury and cyanide by using the DTOX solution from Australia. Now, the next step is to continue to clean areas that have been neglected in past years. One of these areas is in the Boroo River, north of Ulaanbaatar. In 1956, a chemical tank ruptured and leaked approximately five tons of mercury into the

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<sup>68</sup> Ts. Ishigbaatar – Former ninja miner. Personal Interview. 7 Nov 2007. Khanbogd soum, Mongolia.

environment. To date, this site still has not been cleaned and as a result the water still contains mercury, over 50 years after the spill. A recent study showed this area to have levels of mercury higher than the amount permitted by law, but still the mercury remains<sup>69</sup>.

The governments in both Khanbogd and Dalanzadgad both told stories of identifying sites for cleanup but never receiving any answer to their request for the central government to come clean them<sup>70</sup>. Given the number of sites that require cleaning, the government has a lot of work ahead of them. The government should remain open to the possibility of foreign assistance as well as asking companies such as Boroo Gold to assist if possible. The main benefit of cleaning the sites is that then the risk of the pollution eventually finding its way into a source of freshwater (which is then used by a person or animal) is drastically reduced.

Coming to a conclusion about the future of these chemicals is not an easy task. Given that the dangers of mercury are recognized worldwide, this chemical should continue to be banned in all mining activities in Mongolia. Cyanide is a much more tricky issue though. Cyanide can be used safely if the proper precautions are employed. However the danger is always present that if the proper safety measures are not employed then the use of cyanide can quickly lead a very large and life-threatening disaster. Given this fact, cyanide should be strictly reserved for companies that demonstrate a very high standard of

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<sup>69</sup> B. Tumenbayar. *Action Research on Mercury Pollution in Boroo Area in Mongolia*. Japanese International Cooperation Agency 2005.

<sup>70</sup> B. Otgonbayar – Environmental Land Policy Specialist. Personal Interview. 6 Nov 2007. Dalanzadgad, Mongolia.

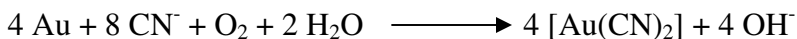
environmental awareness and take every precaution to ensure that the waste is properly handled so no dangerous cyanide is leaked into the environment. This standard supposedly exists in Mongolia, though Buman Trade's operation raises questions over how strictly this standard is enforced given the conditions under which the company operates.

The next few years will go a long way to determining the outcome of this issue in Mongolia. Many people believe that this issue comes down to either banning these toxic chemicals completely or allowing their use at the cost of a clean and safe environment. The goal of this report has been to show, using both positive and negative examples, that with some serious devotion to bringing about long-lasting change it is possible to find some sort of middle ground. While mercury is almost universally recognized as being too dangerous for use in any sort of mining activities (and banned as a result), cyanide can be used by certain trained individuals in a manner that does not negatively affect the surrounding areas. Additionally, gold can be successfully and profitably recovered using chemical-free methods. By taking an intelligent approach to the issue, it will be possible to slowly reduce and finally eliminate the illegal use of these chemicals and thus greatly reduce the environmental impacts of mercury and cyanide on the environment.

## Appendix

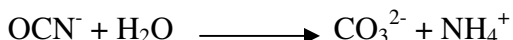
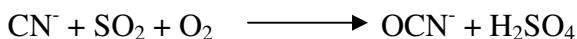
### *RELEVANT CHEMICAL REACTIONS*

#### How Cyanide Reacts With Gold:

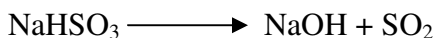
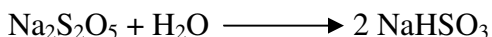


\* The pH must be kept around 10.5 otherwise HCN gas is produced when  $\text{CN}^-$  reacts with water.

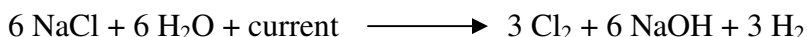
#### Boroo Gold Detoxification Scheme<sup>71</sup>:



\*In the first step, the  $\text{SO}_2$  comes from the reaction of sodium metabisulfite ( $\text{Na}_2\text{S}_2\text{O}_5$ ) with water:

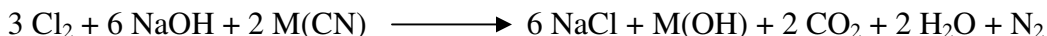


#### Buman Trade's Apparent Decontamination Plan:

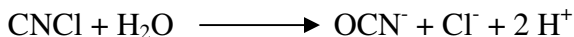
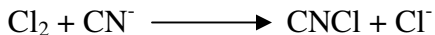


\*This first step requires a current to be effective, otherwise this reaction does not occur. The Buman Trade operation did not appear to have any obvious way of administering a current during the decontamination process.

\*There are two possible paths from here. If the Cyanide is bound to a metal (M) then the following reaction takes place<sup>72</sup>:



\*If no metal is present, then a different reaction sequence occurs:



\*This Cyanate ( $\text{CNO}^-$ ) then decomposes in the same manner as shown above for the Boroo Gold Detoxification Scheme.

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<sup>71</sup> Ocirbat – Boroo Gold Metallurgist. Personal Interview. 14 Nov 2007. Selenge aimag, Mongolia.

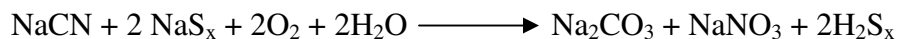
<sup>72</sup> *Treatment of Water Containing Cyanide*. Free Patents Online. 28 Nov 2007. <<http://www.freepatentsonline.com/4029557>>.

### DTOX Reactions<sup>73</sup>:

\*DTOX contains 39% Sodium Polysulfide (NaS<sub>x</sub>) by weight as its active ingredient<sup>74</sup>.



\* HgS is the chemical formula of the naturally occurring mineral cinnabar



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<sup>73</sup> *Sodium Cyanide and Mercury Pollution and Mining Related Environmental Emergencies in Mongolia*. July 2007. United Nations Environmental Programme. 21 Oct 2007  
<<http://ochaonline.un.org/ochaunep>>.

<sup>74</sup> *DTOX Material Safety Data Sheet*. Mineral Process Control Ltd. 28 Nov 2007.  
<[http://www.mineralprocesscontrol.com.au/media/DTOX\\_20MSDS.pdf](http://www.mineralprocesscontrol.com.au/media/DTOX_20MSDS.pdf)>.